WHAT IS CLAIMED IS (US Claim):

1. An intake air amount estimation apparatus for an internal combustion engine, comprising:

a first relational expression setter that sets a first relational expression between an intake pipe pressure and an amount of intake gas flowing into cylinders in the case of a first valve timing of the internal combustion engine wherein a valve timing can be changed in at least two stages between the first valve timing and a second valve timing and wherein an exhaust gas recirculation passage provided with a control valve is connected to an intake pipe downstream of a throttle valve;

a second relational expression setter that sets a second relational expression between the intake pipe pressure and the intake gas amount in the case of the second valve timing;

a first calculator that calculates, in the case of the first valve timing, an amount of recirculated exhaust gas flowing past the control valve which is based on an intake pipe pressure at the time when the control valve is at a specific opening degree, as an amount of intake exhaust gas flowing into the cylinders during steady operation of the engine;

a second calculator that calculates, on the basis of the intake exhaust gas amount and by means of the first relational expression, an amount of intake air that is drawn via the throttle valve at the time when the control valve is at the specific opening degree in the case of the first valve timing; and

a third calculator that calculates, on the basis of the intake exhaust gas amount and by means of the second relational expression, an intake air amount at the time when the control valve is at the specific opening degree in the case of the second valve timing, on the assumption that the intake exhaust gas amount for the specific opening degree based on the intake pipe pressure remains unchanged irrespective of a valve timing.

2. The intake air amount estimation apparatus according to claim 1, wherein

in consideration of the fact that the recirculated exhaust gas flowing past the control valve is drawn into the cylinders with a delay when the internal combustion engine is in transition, the amount of recirculated exhaust gas is corrected

to the intake exhaust gas amount by the first calculator and is used to calculate the intake air amount.

3. The intake air amount estimation apparatus according to claim 1, wherein the intake gas amount is a sum of the intake exhaust gas amount and an amount of air flowing past the throttle valve.

4. The intake air amount estimation apparatus according to claim 1, wherein the intake gas amount is equal to an intake air amount calculated by the second calculator and to an intake air amount calculated by the third calculator if the control valve is completely closed.

5. An intake air amount estimation apparatus for an internal combustion engine, comprising:

a relational expression setter that sets, on the assumption that an amount of recirculated exhaust gas flowing past a control valve which is based on an intake pipe pressure is equal to an amount of intake exhaust gas flowing into cylinders during steady operation of the internal combustion engine wherein a valve timing is variable and wherein an exhaust gas recirculation passage provided with the control valve is connected to an intake pipe downstream of a throttle valve, a relational expression between an intake pipe pressure Pm and an amount KL of intake air drawn via the throttle valve during steady operation of the engine as $KL = e(Pm-g)+r$, using coefficients "e" and "r" that are determined in advance in accordance with an engine speed, the valve timing, and an opening degree of the control valve and a coefficient "g" that is determined in advance in accordance with the engine speed alone or its combination with the valve timing and/or the opening degree of the control valve;

a first calculator that calculates, as an amount of intake exhaust gas flowing into the cylinders during steady operation of the engine, an amount of recirculated exhaust gas flowing past the control valve which is based on an intake pipe pressure at the time when the control valve is at a specific opening degree; and

a second calculator that calculates, on the basis of the intake exhaust gas amount and by means of the relational expression, the intake air amount at the time when the control valve is at the specific opening degree.

6. The intake air amount estimation apparatus according to claim 5, wherein

in consideration of the fact that an amount of recirculated exhaust gas flowing past the control valve is drawn into the cylinders with a delay when the internal combustion engine is in transition, the amount of recirculated exhaust gas flowing past the control valve as an amount calculated by means of the relational expression is corrected to the intake exhaust gas amount by the first calculator and is used to calculate the intake air amount.

7. The intake air amount estimation apparatus according to claim 5, wherein

the intake gas amount is a sum of the intake exhaust gas amount and an amount of air flowing past the throttle valve.

8. The intake air amount estimation apparatus according to claim 5, wherein

the intake gas amount is equal to an intake air amount calculated by the second calculator if the control valve is completely closed.

9. An intake air amount estimation method for an internal combustion engine, comprising the steps of:

setting a first relational expression between an intake pipe pressure and an amount of intake gas flowing into cylinders in the case of a first valve timing of the internal combustion engine wherein a valve timing can be changed in at least two stages between the first valve timing and a second valve timing and wherein an exhaust gas recirculation passage provided with a control valve is connected to an intake pipe downstream of a throttle valve;

setting a second relational expression between the intake pipe pressure and the intake gas amount in the case of the second valve timing;

calculating, in the case of the first valve timing, an amount of recirculated exhaust gas flowing past the control valve which is based on an intake pipe pressure at the time when the control valve is at a specific opening degree, as an amount of intake exhaust gas flowing into the cylinders during steady operation of the engine;

calculating, on the basis of the intake exhaust gas amount and by means of the first relational expression, an amount of intake air that is drawn via the

throttle valve at the time when the control valve is at the specific opening degree in the case of the first valve timing; and

calculating, on the basis of the intake exhaust gas amount and by means of the second relational expression, an intake air amount at the time when the control valve is at the specific opening degree in the case of the second valve timing, on the assumption that the intake exhaust gas amount for the specific opening degree based on the intake pipe pressure remains unchanged irrespective of a valve timing.

10. The intake air amount estimation method according to claim 9, wherein

in consideration of the fact that the recirculated exhaust gas flowing past the control valve is drawn into the cylinders with a delay when the internal combustion engine is in transition, the amount of recirculated exhaust gas is corrected to the intake exhaust gas amount and is used to calculate the intake air amount.

11. The intake air amount estimation method according to claim 9, wherein

the intake gas amount is a sum of the intake exhaust gas amount and an amount of air flowing past the throttle valve.

12. The intake air amount estimation method according to claim 9, wherein

the intake gas amount is equal to a calculated amount of intake air if the control valve is completely closed.

13. An intake air amount estimation method for an internal combustion engine, comprising the steps of:

setting, on the assumption that an amount of recirculated exhaust gas flowing past a control valve as an amount based on an intake pipe pressure is equal to an amount of intake exhaust gas flowing into cylinders during steady operation of the internal combustion engine wherein a valve timing is variable and wherein an exhaust gas recirculation passage provided with the control valve is connected to an intake pipe downstream of a throttle valve, a relational expression between an intake pipe pressure Pm and an amount KL of intake air drawn via the throttle valve during steady operation of the engine as $KL = e(Pm-g)+r$, using coefficients "e" and "r" that are determined in advance in accordance with an engine speed, the valve timing, and an opening degree of the control valve and a coefficient "g" that is determined in

advance in accordance with the engine speed alone or its combination with the valve timing and/or the opening degree of the control valve;

calculating, as an amount of intake exhaust gas flowing into the cylinders during steady operation of the engine, an amount of recirculated exhaust gas flowing past the control valve which is based on an intake pipe pressure at the time when the control valve is at a specific opening degree; and

calculating, on the basis of the intake exhaust gas amount and by means of the relational expression, the intake air amount at the time when the control valve is at the specific opening degree.

14. The intake air amount estimation method according to claim 13, wherein

in consideration of the fact that an amount of recirculated exhaust gas flowing past the control valve is drawn into the cylinders with a delay when the internal combustion engine is in transition, the amount of recirculated exhaust gas flowing past the control valve as an amount calculated by means of the relational expression is corrected to the intake exhaust gas amount and is used to calculate the intake air amount.

15. The intake air amount estimation method according to claim 13, wherein

the intake gas amount is a sum of the intake exhaust gas amount and an amount of air flowing past the throttle valve.

16. The intake air amount estimation method according to claim 13, wherein

the intake gas amount is equal to an intake air amount calculated if the control valve is completely closed.